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The Case for Urban Food Security: A Singapore Perspective

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The state of food security can differ in urban and rural environments, as well as in net food-importing and net food-exporting countries. Considering food security in a general manner is no longer adequate for planning anticipatory and response strategies. In this NTS Perspectives, we propose the concept of Urban Food Security, and discuss the need to circumscribe the concept in order to identify more cogent approaches to de-securitise the issues in urban food insecurity. The discussion is placed in the Singapore context and is characterised by the need to develop successful strategies to ensure security in an urban, high-income and net food-importing country. Singapore is illustrative of the global urbanisation process and the issues arising from the development of megacities.

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Executive Summary

Overview

This paper examines the basic concepts of food security and proposes a conceptual model built on the four dimensions of food security: availability, physical access, economic access and utilisation. While each dimension is necessary for overall food security, the importance of each will likely differ in a rural setting as compared with an urban setting and also across countries with different incomes and net food trade balances. Therefore, addressing food security in a general manner is no longer adequate for planning anticipatory and response strategies. Here, the authors argue the case for why an urban focus must be taken into consideration in the international discourse on general food security, and explore different options for a highly urban, high-income and net food-importing country like Singapore. The authors believe that Singapore is illustrative of the urban centres of the future, that is, cities which would emerge as result of the massive ongoing global urbanisation process.

Discussion

The food crisis in 2007–2008 highlighted the fact that even a high-income country like Singapore is not immune to disruptions in the global food supply chain and to price fluctuations. While the dimensions of physical access, economic access and utilisation of Singapore's food security were revealed to be sound, the food crisis illustrated the vulnerability of its food availability dimension. As a small country with limited natural resources, Singapore imports over 90 per cent of the food requirements for its 4.9 million inhabitants; more worrying is the fact that key products are imported from just one or two sources. Trade, therefore, is absolutely critical to Singapore's food security and any disruption in production in any of its key supplier countries could have significant consequences.

Due to such overwhelming dependency on external food sources, some evolving strategies have been identified to ensure food resilience for Singapore's growing population.

First, increasing local farm productivity in Singapore's 'hinterlands' will help reduce its dependence on outside sources. Singapore has made a strategic decision to focus its R&D efforts on increasing production of eggs, fish and leafy vegetables.

It is imperative for Singapore to diversify its food supply sources so as not to rely too heavily on a single or a few exporting countries for some of its main food items. Singapore's Agri-Food and Veterinary Authority (AVA) and International Enterprise (IE) Singapore have been working together to explore new sources of produce and seek new agribusiness opportunities with other countries in the region and further afield.

Another strategy that Singapore has identified to diversify food supply sources is to promote the use of product substitutes particularly liquid or powdered eggs and frozen pork cuts instead of fresh chilled pork meat.

The stockpiling of essential food products is advantageous as it is easily implemented at the local level. However, the optimal volume of food which can be stockpiled and kept fresh at any period of time needs to be carefully evaluated.

A more recent approach that is grabbing media attention is the concept of securing food at source. Singapore has intensified efforts in this area through foreign investments, contract farming and the creation of a designated 'food production and processing zone' situated in another country.

Urban farming is one of those under-appreciated strategies that could help improve urban food security in Singapore and therefore ought to be considered as part of the toolkit to address current and future challenges. Singapore is already using cutting-edge methods such as hydroponics, aeroponics and aquaponics for the production of fresh vegetables, flowers, fruit and fish.

Lastly, Singapore could play a significant role in regional food security. Its high level of economic development, strategic location, R&D capabilities, technology- and business-friendly environment, and stringent food safety standards allow Singapore to serve as an honest broker and 'neutral mediator' in a number of initiatives in the region.

Recommendations

The food crisis at the end of the last decade exposed the vulnerability and fragility of the current global food system and highlighted the increasing problem of urban food security. This paper highlights two main sets of recommendations:

Urban Food Security

- National governments and policymakers need to consider urban food security in its own right while recognising its strong inter-relationships with the wider discourse on food security and to the global food supply chain.
- Policies and programmes need to better reflect the urban context.

Singapore's Food Security

- With increasing incomes, a projected population of 5.5 million (from the current 4.9 million) and an average of 10 million visitors annually, Singapore must take food security more seriously if it wishes to sustain a world-class, high-quality standard of living for all.
- Singapore must harness the best that science and technology have to offer, to increase local agricultural production, improve handling, minimise wastage, optimise productivity and enhance food safety.
- In order to reduce dependency on a single or a few exporting countries, Singapore must continue to find multiple sources for current food imports and explore innovative partnerships with those countries.
- As an honest broker and neutral mediator, Singapore must recognise the significant role it can play in regional food security.
- Singapore must embark on a broad-based, multi-sectoral, cross-nation approach to ensure urban food security. A new paradigm is needed which views national food security in the light of regional and global food security.

Introduction

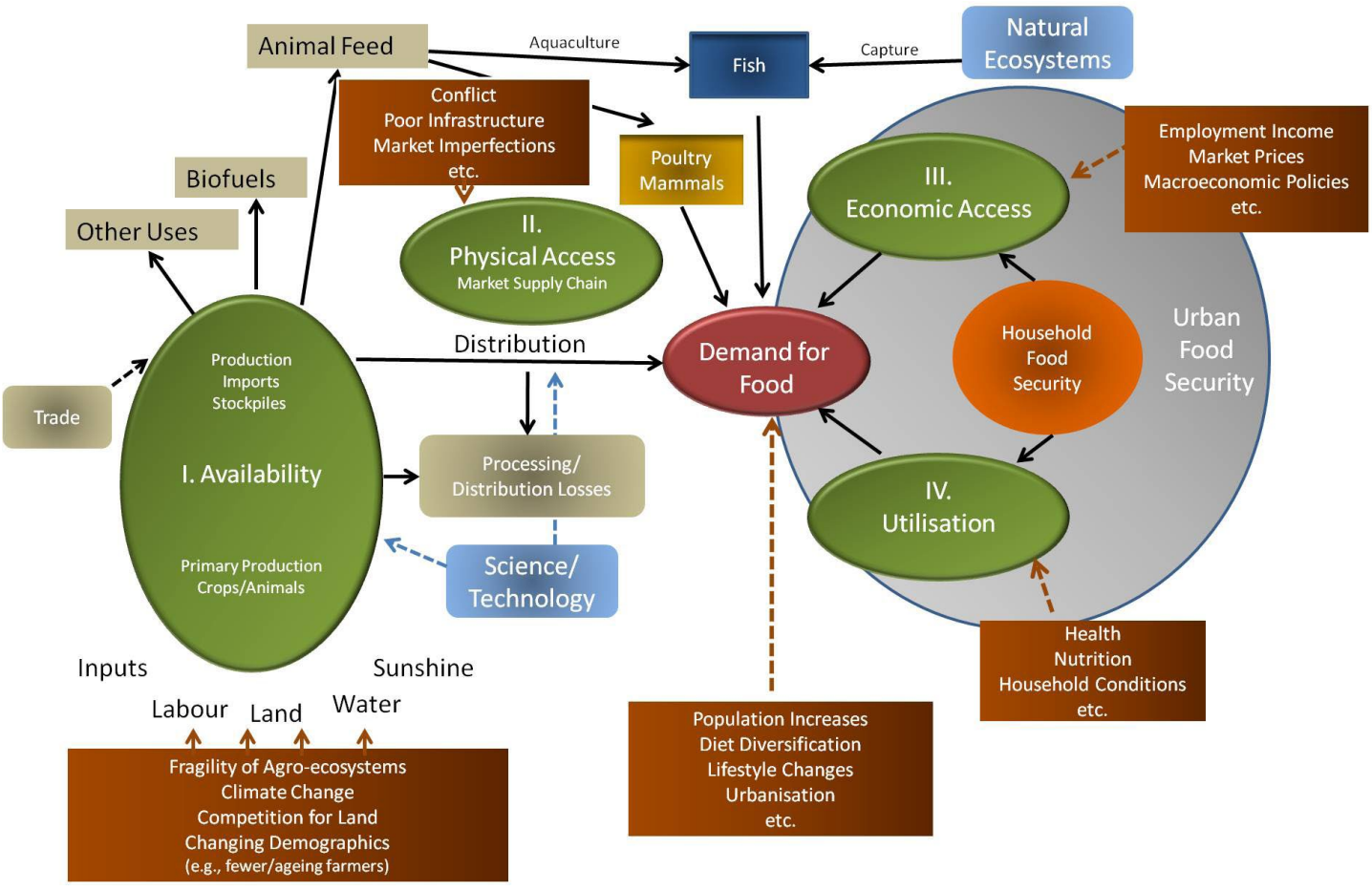
A household is said to be food secure only if it can be protected against both transitory and chronic food insecurity (IFAD, n.d.). The former may afflict any household regardless of whether the latter exists. Crop failure, seasonal scarcities, rising prices, temporary illness or unemployment among the productive members of the household, or perhaps an emergency need for a large cash outlay, may all be reasons for the sudden reduction of a household's access to food to below the nutritionally adequate level. Chronic food insecurity, on the other hand, occurs when a household is persistently unable to meet the food requirements of its members over an extended length of time, a period punctuated with good and bad episodes. Teng and Escaler (2010) identified some of the main drivers of both types of food insecurity and described how they can directly affect urban food security.

Basic Concepts of Food Security

In this NTS Perspectives, we propose a conceptual model built on the four dimensions of food security (see Figure 1). In this model, food security, whether in a rural or urban setting, is described as a complex interplay of forces and is more than just an issue of supply and demand. The four dimensions of food security are considered to be: availability, physical access, economic access and utilisation. While each dimension is necessary for overall food security, they likely have different weightings in a rural setting as compared with an urban setting and also across countries with different incomes and net food trade balances.

The first dimension of food security is availability of food. This dimension addresses the supply side of food security and is determined by the level of food production, stock levels, food aid and net trade (Riely et al., 1999). Here, raising farm productivity is the core issue, whether by accessing or increasing inputs, improving seed

Figure 1: Conceptual model for food security



varieties, or employing better farm management practices. As the model indicates, food availability can be influenced by agro-climatic conditions and an entire range of socioeconomic and cultural factors that determine where and how farmers perform in response to market conditions. 'Availability' can refer to food supplies at the household level but is most commonly used to refer to food supplies on a more expansive (national/regional/global) level. Food availability is often the focus of much of the debate on food security but as the model illustrates, raising farm productivity, although necessary, is not sufficient to ensure household food security.

The second dimension is physical access to food. This means an adequate amount of food must be within the physical reach of vulnerable households, whether through their own production or through the marketplace. Common threats to physical access to food are war, civil strife, poor infrastructure, inadequate logistics for food distribution and market imperfections. Such problems are more likely to exist in rural areas characterised by difficult terrain and remoteness. In an urban setting, however, raising the efficiency of market supply chains to deliver food to consumers is the primary concern. According to Reardon (2010), 50 to 70 per cent of consumers' cost of food is formed in post-farm-gate segments of supply chains, e.g., wholesale, logistics, processing and retail. The 'supermarket revolution' is taking place in urban areas across the world. Supermarkets have now gone beyond catering to the initial middle- and upper-class clientele in many countries to reach the mass market. Though supermarket chains will no doubt capture more of the retail share in the future, they may not be of immediate relevance to the urban poor who lack the cash to purchase in bulk (Cohen and Garrett, 2009). These people will continue to purchase food on a daily basis from street vendors or small corner stores that may also offer credit.

The third dimension is economic access to food or the ability of the household to purchase the food it requires. This is the dimension most relevant to urban residents who have to purchase almost all of their food as well as other goods and services. Thus, a key element of this dimension is the purchasing power of consumers and the evolution of real incomes and food prices. As the most recent food crisis demonstrated, urban households were among the hardest hit as they saw their purchasing power decline drastically and they had very limited capacity to produce their own food. Therefore, urban food security depends to a large extent on individual household circumstances as the household operates within a more complex purchasing environment (Cohen and Garrett, 2009). Given the unique challenges of the urban environment, urban dwellers face more threats to their economic access to food compared to their rural counterparts (Teng and Escaler, 2010). Additional factors that will influence economic access include employment and income security, macroeconomic policies, social security programmes, and of course, the availability of food through its impact on supplies in the market, and therefore on market prices.

The fourth dimension is food utilisation. A household may have the capacity to purchase all the food it needs but it may not always have the ability to utilise that capacity to the fullest. Food utilisation – which is typically reflected in the nutritional status of an individual – is determined by the quantity and quality of dietary intake, general child care and feeding practices, food preparation, food storage, along with health status and its determinants (Riely et al., 1999). It is not enough that an individual is getting what appears to be an adequate quantity of food if that person is unable to consume the food because he or she is always falling sick. The urban poor are subject to crowded living conditions characterised by poor quality housing, poor or non-existent garbage disposal systems, unsafe drinking water, and non-functional or non-existent sewage systems which could all affect the nutritional status of residents in the form of malnutrition and poor health. In addition, because urban residents often face time constraints and have greater exposure to advertising and easier access to supermarkets and fast-food vendors, they often opt for more processed and prepared foods which mean higher intakes of saturated and total fat as well as sugar, and lower intake of fibre (Garrett and Ruel, 2000). This diet, together with a more sedentary lifestyle in cities, increases the risk of chronic diseases including diabetes

and obesity, diseases associated with wealth and industrialisation. Thus the determinants of nutritional status go beyond income alone. Food availability is not enough for good nutrition.

A household can be said to be food secure only if it is secure in terms of both the access and the utilisation of food. However, numerous factors may influence each dimension of food security at any given time and in a variety of ways, thus affecting the overall food security of the household.

As mentioned earlier, the individual dimensions of food security may carry different weight in rural and urban settings. The urban environment, particularly in a developing country, presents more challenges vis-à-vis food security that differentiates it from the countryside. Urban residents have to purchase almost all of their food as well as other goods and services. Due to increased incomes, there is a higher demand for more expensive sources of nutrients such as meat, fruit and vegetables. Also, because of the shift from staples such as sorghum to millet, as well as maize and root crops to rice and wheat in urban areas, the urban poor may be more vulnerable than their rural counterparts to variations in the international market since rice and wheat, along with maize, tend to be internationally traded items. Many urban residents are also more vulnerable to global economic events since they depend on overseas remittances, exports, employment, Foreign Direct Investment, etc. Since urban areas are centres of economic opportunity, there is a greater percentage of women working outside the home and studies have indicated that the increased opportunity cost on women's time due to work increases the demand for processed and fast food in many countries as such food requires less preparation time. In addition, the urban poor live in crowded living conditions with poor quality housing, poor to non-existent garbage disposal systems, unsafe drinking water, and non-functional or non-existent sewage systems. Lastly, the jobs of the urban poor are casual, insecure, uncertain, low-paying and vulnerable to outside forces.

In addition to the above, many fast-growing cities, particularly in developing countries, are now showing signs of a 'new' kind of poverty in addition to the 'old' – 'old' being the lack of food and access to basic services and 'new' being drug addiction, violence, family breakdown and environmental degradation (How to Get Children, 2010). These 'new' problems which also affect household food security are more complex and demand more innovative solutions.

It is because of such factors that economic access and food utilisation may feature more prominently in the overall urban food security equation. As the recent food crisis demonstrated, though aggregate world food availability was relatively good during this period, access to and utilisation of that food by the urban poor in many developing countries were severely compromised.

Urban Food Security and Singapore

Though it seems paradoxical to talk about Singapore and food security, the food crisis in 2007–2008 highlighted the fact that even a high-income country like Singapore is not immune to disruptions in the global food supply chain and price fluctuations. While the dimensions of physical access, economic access and utilisation of Singapore's food security were revealed to be sound, the food crisis illustrated the vulnerability of its food availability dimension (see Figure 1). Prices of imported food increased by 12.1 per cent between December 2006 and 2007 (Ramesh and Perry, 2008). Being a highly urbanised and densely populated city-state, Singapore's approach to ensuring food resilience for its growing population could potentially serve as a guide for other high-income, food-importing countries such as Japan, South Korea, Taiwan and the Gulf states aiming to achieve urban food security.

Singapore's Current and Future Food Requirements

As a small country with limited natural resources, Singapore imports over 90 per cent of its food requirements (see Table 1) for its 4.9 million inhabitants. In 2008, Singapore imported more than 2.4 million tonnes of unprocessed food

Table 1: Consumption, import and local farm production (Jan–Dec 2008)

	Beef (tonnes)	Chicken (tonnes)	Cooking Oil (tonnes)	Duck (tonnes)	Fish (tonnes)	Fruit (tonnes)	Hen Eggs (million pcs)	Mutton (tonnes)	Pork (tonnes)	Rice (tonnes)	Sugar (tonnes)	Vegetables (tonnes)
Consumption	19,360	158,108	172,128	14,925	84,219	338,904	1,453.7	9,824	92,768	274,605	232,784	399,778
Import	28,848	165,287	491,824	15,049	82,645	361,766	1,117.0	10,014	93,260	288,555	412,061	394,162
Local Farm Production		1,667			5,141		337.8					18,967

Source: AVA Annual Report 08/09 (2009)

supplies which included 93,260 tonnes of pork, 165,287 tonnes of chicken and 288,555 tonnes of rice (see Table 1). One of the main concerns for Singapore is that key products are imported from just one or two source countries. For example, according to the Singapore Department of Statistics, a large portion of Singapore's pork imports (57 per cent) is from Brazil while the rest are from Indonesia's Pulau Bulan and Australia. Singapore imports most of its vegetables from Malaysia (46 per cent) and China (28 per cent), while most of Singapore's eggs come from Malaysia, with a minority (27 per cent) from local farms. All of Singapore's fresh chicken is imported from Malaysia while 84 per cent of all frozen chicken comes from Brazil (Yeo, 2008).

Singapore's per capita food consumption is comparable with that of other developed countries and sometimes even higher in the case of certain food products, e.g., poultry (chicken and duck) and hen eggs (see Table 2). Singaporean consumers tend to demand high quality poultry, pork, seafood, vegetables and fruits particularly as a consequence of income growth (Tey et al., 2009). As such, there is a pressing need to ensure that Singapore is able to secure a minimal amount of these food items during a crisis. Any disruptions in key parts of the food supply chain can have significant consequences.

Table 3 represents the average monthly household expenditure on food for 2007–2008. Singaporean households spend, on average, 21.6 per cent of their monthly income on food, of which a significant proportion (63 per cent) is spent on meals in restaurants, food courts, hawker centres, etc. At home, they spend most

Table 2: Per capita food consumption (kg/person/year)

Item	Singapore (2009)	World	Source
Chicken	31.6	23.7[a]	(European Commission, 2002)
Pork	19.1	42.8[b]	(FAOSTAT, n.d.)
Beef	4.0	18.0[b] - 43.2[c]	(USDA FAS, 2006)
Duck	2.7	0.4[d] - 2.5[e]	(Yan, 2002)
Mutton	2.1	1.9[f] - 2.6[b]	(FAOSTAT, n.d.)
Fish	16.4	16.7[f], 60.8[g]	(FAOSTAT, n.d.)
Vegetables	83.8	119.5[f]	(FAOSTAT, n.d.)
Fruits	69.1	69.1[f]	(FAOSTAT, n.d.)
Hen eggs	18	8.6[f] - 14.3[c]	(FAOSTAT, n.d.)

Notes: a. Developed world – 2000; b. European Union – 2007; c. USA – 2007; d. World average – 2002; e. Hong Kong – 2002; f. World – 2007; g. Japan – 2007

Source: Modified from Cheong (2007)

Table 3: Average monthly household expenditure on food, 2007/08

Food Products	Share (%)
Rice & other cereals	1.5 (7)
Meat	1.3 (6)
Fish & seafood	1.3 (6)
Dairy & eggs	0.8 (4)
Oils & fats	0.2 (1)
Vegetables	1.0 (5)
Fruits	0.8 (4)
Sugar, preserves & confectionery	0.3 (1.5)
Non-alcoholic beverages	0.5 (2)
Other foods	0.1 (0.5)
Food serving services	13.5 (63)
TOTAL	**21.6 (100)**

Source: Singapore Department of Statistics (2009b)

of their food budget on rice and other cereals, seafood, meat, vegetables, dairy and eggs, and fruits.

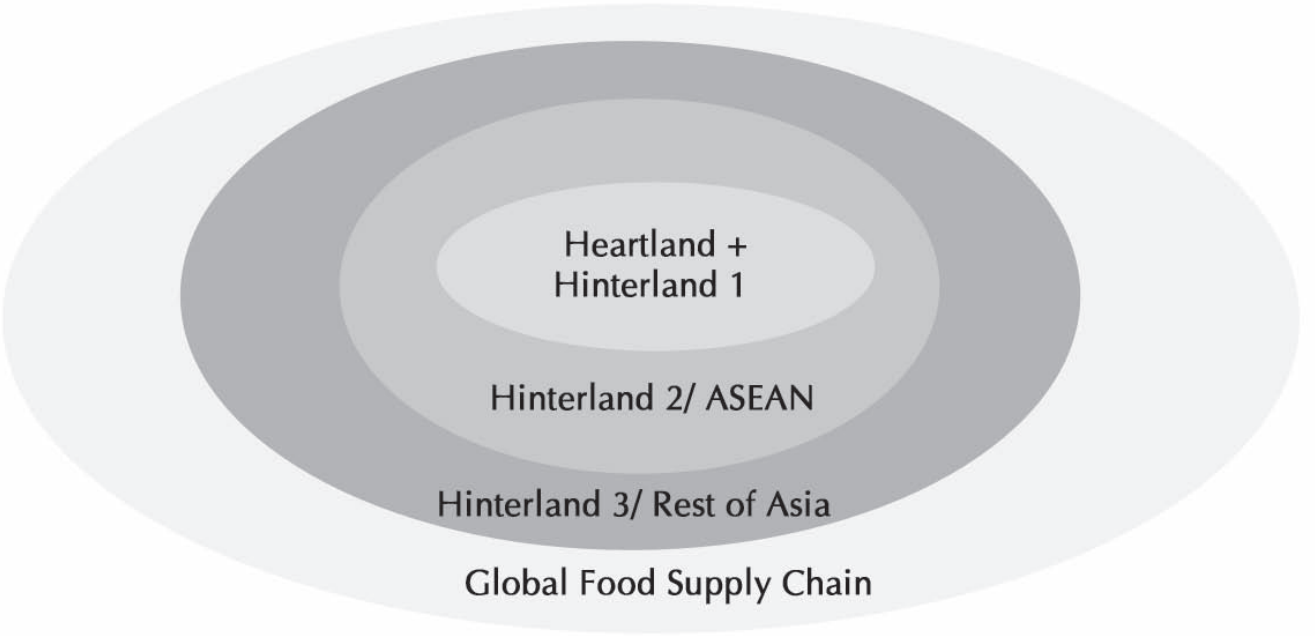
With increasing incomes and a projected rise in population to 5.5 million (from the current 4.9 million) – mainly through immigration – Singapore's food demands will grow to place an enormous strain on current resources. As it is, Singapore is the tourist and transportation hub of Southeast Asia and boasts a very large food service industry with a vast array of hotels, restaurants, airline caterers, integrated resorts, ship handlers, hospitals and clubs. The country's multi-racial society and the presence of a large expatriate population have led to a diverse and rich variety of food types being made available to consumers. Over 11 million tourists and business travellers are expected to visit Singapore in 2010 (Singapore Tourism Board, n.d.). In order to maintain urban food security, Singapore will have to increase the development and adoption of new technologies and explore innovative ways to sustain a world-class, high quality standard of living for all.

Singapore's 'Hinterlands'

Singapore compensates for its small size and scarce land and water resources by being strategically located in an agriculturally rich region and by having a deep natural harbour. Singapore's bustling port is the largest and one of the busiest (in terms of total shipping tonnage) in the world (Singapore Crowned, 2010). It is connected to 600 other ports in 123 countries spread over 6 continents (PSA, n.d.). In 2005, its terminals accounted for 20 per cent of the global transhipment throughput and about 6 per cent of the world's container throughput. Singapore's Changi Airport is served by over 80 scheduled airlines operating some 5,000 weekly scheduled flights to 200 cities in about 60 countries and territories (Changi Airport Singapore, n.d.).

Just as urban cities all over the world rely on their hinterlands and rural areas for food supplies, Singapore depends primarily on its own 'hinterlands'. For the purpose of conceptualising food security, Figure 2 illustrates Singapore's 'hinterlands' which extend to the region. The island state of Singapore, as represented by the central circle, consists of a land area comprising 'heartlands' (urban settlements with gardens) and six delineated agricultural 'hinterlands'. Unbeknown to many, agriculture in Singapore still remains a part of the country's total economic activity. Though it accounts for only 0.2 per cent of the country's gross domestic product (GDP) and employs a mere 0.2 per cent of the workforce, agricultural systems on the island are intensive. At present, agriculture in Singapore takes place in its hidden hinterland of agrotechnology parks or modern agriculture estates. There are six such parks in Singapore. These parks cover a land area of 1,465 hectares (ha) and nearly 700 ha (1.6 per cent of Singapore's total land area) have been allocated to over 200 farms for the production of livestock, eggs, milk, aquarium and food fish, vegetables, fruits, orchids, ornamental and aquatic plants, as well as for the breeding of birds and dogs. The modern farms in these agrotechnology parks develop, adapt and showcase advanced technologies and techniques for intensive farming systems, and for the export of high value and quality products and services to other tropical countries in the region (AVA, n.d., 'Agrotechnology Parks').

Figure 2: Singapore's 'hinterlands'



Just outside of Singapore's borders lies its second 'hinterland' consisting of fellow ASEAN (Association of Southeast Asian Nations) member countries, some of which are the world's top producers of major agricultural commodities. Due to proximity, Malaysia, Indonesia and Thailand provide a significant proportion of the more perishable items, such as hen eggs, fruits and vegetables, chilled fish, and chilled chicken and pork. Most of the produce from peninsular Malaysia and Thailand are transported by road through the Johor-Singapore Causeway and the Malaysia-Singapore Second Link. Singapore's dependency and trade with this proximate food producing area is longstanding and based on strong historical ties.

Further afield, Singapore looks to the rest of Asia ('Hinterland 3') with China and Australia among its top suppliers, and then ultimately to the rest of the world through the global food supply chain for the remainder of its food requirements. Singapore's excellent sea and air links and telecommunications allow it to readily order and obtain supplies from any one of its 'hinterlands'. Trade, therefore, is absolutely critical to Singapore's food security and any disruption in production in any of its key supplier countries could have significant consequences.

Risk Scenarios Affecting Singapore's Food Security

For an urban, high-income and net food-importing country like Singapore, food insecurity results mainly from threats to its food availability dimension. The higher the degree of import dependence, the higher the risks the country is exposed to. This is the reason why Singapore should be sensitive to declining food self-sufficiency. Three general risk scenarios have been identified that could threaten Singapore's food availability:

1. Supply lockdown in exporting countries (e.g., in cases of disease outbreaks or extreme weather in the exporting countries) – Supply lockdowns usually occur without warning and are often short-term. Usually, acceptance of short-term non-availability is necessary to 'weather out' this type of crisis.
2. High intensity conflict (e.g., war) – The duration of such disruptions is often hard to determine. In such cases, sourcing for alternative sources of food is most pressing.
3. Low intensity conflict (e.g., regional socioeconomic instability or terrorist threats) – Usually, such cases lead to long-term disruptions in food supplies. Having a variety of food choices as well as food sources is usually important in surviving such conflicts.

Small farmers in many developing countries still remain low on the economic ladder because of low on-farm prices for their produce, low investments in agriculture and small farm units.

In addition to the above, other supply-side risks include disruptions in shipping and transport systems (see Dimension II, Figure 1) and the sudden emergence of strong competitors for food in the world market. Singapore Food Industries has identified items such as oils, milk powder and rice as highly important during a food emergency and noted that ensuring their year-round availability should be of utmost importance.

While Singapore may not appear to have specific demand-side risks – i.e., lack of purchasing power – the threats described above will indirectly affect physical and economic access to food because as agricultural production declines and competition arises, food prices rise, and purchasing power decreases. Lastly, greater exposure to advertising and easier access to supermarkets and fast-food vendors cause diets to move away from staples towards more livestock products, fats and sugars. This, combined with a sedentary lifestyle, may increase the risk of chronic diseases including obesity, diabetes and heart disease, thus affecting food utilisation.

Evolving Strategies to Reduce Risk and Ameliorate Singapore's Food Insecurity

Given Singapore's current overwhelming dependency on external food sources, what are some possible strategies to manage food insecurity resulting from any of the four dimensions of the conceptual model? This section explores some evolving strategies which are also of particular relevance to other net food-importing countries.

Increasing local farm productivity in Singapore's 'hinterland'

At present, local farming accounts for 23 per cent of eggs, 4 per cent of fish and 7 per cent of leafy vegetables consumed in Singapore (AVA's $5m Food Fund, 2010). However, in light of the recent food crisis, the Government of Singapore through its Agri-Food and Veterinary Authority (AVA) has established a Food Fund which was recently increased to S$10 million with the aim of increasing self-sufficiency levels to 30 per cent of eggs, 15 per cent of fish and 10 per cent of leafy vegetables consumed in Singapore in the next five years. The key focus areas in R&D projects include: variety selection and development of seed banks for vegetables, farming systems and post-harvest processes for vegetables, breeding and farming systems for fish and waste treatment systems for poultry.

Over the years, significant advancements have been made in the development of fish reproduction technology for cobia, the genetic selection of Asian seabass as well as the development of large-scale hatchery technology. Further, the

AVA has collaborated with a Norwegian company to explore the possibility of establishing a saline-tolerant marine tilapia strain. This project has the potential to move tilapia farming from freshwater to marine coastal waters. The AVA also helped to facilitate the setting-up of a large-scale open water seabass farm off Pulau Semakau by a local company. With all these developments, the AVA noted that Singapore has the potential to meet 15 per cent of its total fish consumption compared to only 4 per cent today.

Given the importance of vegetables in the Singapore diet and the heavy reliance on only one or two main suppliers, the government has invested some efforts into R&D in vegetable production, albeit in a limited fashion. For example, a joint study by the AVA, a local polytechnic, a local farm and a supermarket chain was conducted to establish the temperature profile of the local vegetable supply chain with the aim of improving its existing operations to lower the risk of temperature breaches within the cold chain. The AVA also introduced the cultivation of tomatillo to local vegetable farms both as a supplementary crop for crop rotation and an income supplement for farmers.

The AVA also focuses on applied research in post-harvest technology to improve handling and shelf-life, minimise wastage, optimise productivity and enhance food safety. Ultimately, the aim is to develop best practices for the handling and distribution of food products to ensure the quality and safety of food products and reduce post-harvest losses.

Another avenue for improvement is through the country's aeroponics and aquaponics technologies where advancements and intensification would allow Singapore to supply its population with more food in a crisis. This will be discussed in further detail later on.

Diversifying food sources

Finding multiple sources for current food imports is important to reduce Singapore's food dependency on a single or a few exporting countries. In the meat category, Singapore relies very heavily on Australia and New Zealand for beef and mutton products. Malaysia is the main supplier of fruits, vegetables, fresh chicken and seafood, and Brazil for frozen chicken meat (Tey et al., 2009). Singapore has banned Malaysian pork products since the outbreak of Nipah virus in 1999, and as a result a large portion of Singapore's pork imports are from Australia, Brazil and Indonesia's Pulau Bulan.

The AVA is working closely with International Enterprise (IE) Singapore to identify multiple sources for some of Singapore's main food items. For vegetables and fruits, they have organised visits to Vietnam, Thailand and Indonesia to explore new sources of produce and seek new agribusiness opportunities. For seafood, they have signed contracts with local companies in Vietnam and for meat and eggs, the AVA and IE Singapore have established networks in Brazil, Mexico and Peru.

Modern technology for specialised farming such as aquaculture requires significant financial investment to make it environment friendly.

A wet market in Singapore.

To further facilitate the diversification of food supply sources, the AVA has formed food business clusters which provide a platform for it to work closely with industry to identify and address challenges in food supply, develop diversification strategies and explore new food sources and investment opportunities.

The diversification of food supply sources, on the other hand, can also pose some challenges, the most important of which is ensuring food safety. With food sourced from multiple countries around the world, Singapore must make sure high food safety standards are in place to safeguard public health. To maintain its reputation for providing safe and high quality food, it must pay close attention to each aspect of the food production process – from the conditions of the farms, slaughterhouses and food processing establishments (both local and overseas), to the testing of food samples for chemical and biological contaminants.

Promoting the use of product substitutes

Another strategy to diversify food supply sources is to promote the use of product substitutes, such as liquid and powdered eggs as an alternative to shell eggs, and frozen pork cuts instead of chilled pork. In the case of eggs, the AVA, in collaboration with Temasek Polytechnic in Singapore, works with various food associations, such as the Singapore Bakery and Confectionery Association, to introduce the use of powdered eggs for cake baking. In the case of pork, industry has taken the lead by introducing suitable cuts of frozen pork to local consumers (Cheong, 2007).

Stockpiling of essential food products

This approach is advantageous as it is easily implemented on a local level. However, there has to be consideration of the optimal volume of food which can be stockpiled and kept fresh at any period of time. The creation of a 'right to call' option for forward purchasing arrangements with partner countries might be a way around this issue. This option requires that Singapore and a large supplier commit to the assurance of food supply through contractual agreements. In the case of a food emergency, the supplier would thus be bound by contract to provide food for Singapore's needs.

Securing food at source

Shaken by the food crisis of 2007–2008, Singapore has intensified efforts to secure food at source, through foreign investments and contract farming, to guarantee a stable supply of food at affordable prices. The AVA estimates that, overall, Singapore buyers now have in place 20 contract farming agreements with farmers in countries such as China and Malaysia, up from only 5 contracts three years ago. Now, 5 per cent of the vegetables consumed in Singapore are grown under contract, compared with half as much three years ago. About half of the 120,000 live chickens that come into Singapore daily from Malaysia are also bred under contract. Three years ago, none were. Contract farming for fish has also taken off. Contract farming provides greater quality control, as well as price and supply stability. A side benefit of contract farming is that, inevitably,

producers are influenced by the safety standards and best management practices stipulated by Singapore buyers, resulting in a win-win situation for consumers and the environment.

Another project which Singapore is in the process of implementing is the creation of a designated food zone (China, Singapore Food Zone, 2010). A food zone is a 'food production and processing zone' created in an existing agricultural country where the input, processes and outputs to the market will be controlled through product specifications/guidelines, with monitoring and product testing to ensure that the products meet international food quality and safety requirements (Yeo, 2008). The food zone could be situated in another country such as China or Indonesia where relative food production volumes are larger than Singapore's, implying relatively lower costs to transport food to Singapore. In such a case, the creation of a food zone would also provide the people of the host country with employment opportunities. This zone should ultimately create an economically competitive (affordable), productive and safe source of food that can feed the populace. From an operational point of view, this food zone would be run as a joint venture/ partnership between a Singapore entity and the local government hosting the food zone. For this to be a win-win partnership, an efficient business model needs to be designed, which will bring in knowledgeable and qualified operators and managers. The project must be sustainable and serve local commercial needs apart from those of Singapore.

Championing urban farming among the local population

Though farming and agriculture may seem alien to most Singapore residents, the recent food crisis was a wake-up call to look for more creative approaches to ensure Singapore's food security in a country so heavily reliant on imports. Urban farming ought to be considered part of the toolkit to address current and future challenges. Singapore's residential and commercial rooftops could be transformed into 'sky farms' for the production of fresh vegetables, flowers and fruits using cutting-edge farming technology (Wilson, 2005). Singapore is already a global leader in hydroponic and aeroponic technologies which are very successful for growing temperate-climate fresh vegetables (such as lettuce) in sub-tropical and tropical conditions. Hydroponics is a method of growing plants in nutrient solutions without soil. Usually, the roots of the plants are submerged in water enriched with chemicals necessary for growth. Aeroponics, an offshoot of hydroponics, is a method of growing plants with the roots suspended in the air. The plants are anchored in holes, atop a panel of polystyrene foam. From a sealed trough below, a fine mix of soluble nutrients is sprayed onto the roots. Besides generating substantial savings in water and land, two of Singapore's most prized assets, the method also produces cleaner vegetables as they are cultivated in a protected environment. A survey by Singapore's Ngee Ann Polytechnic students found that four suburban areas of northern Singapore (about one fifth of the total built environment in Singapore) had about 212 ha of apartment and commercial rooftop space to potentially grow fresh vegetables, using inorganic hydroponics (Wilson, 2005). About 39,000 tonnes of vegetables a year could be produced from the 212 ha. If these vegetables were sold for around S$2/kg, the value of the produce would be estimated at S$40 million a year.

Since seafood, and in particular, fish, is such a large part of the Singapore diet, another high-tech farming method that could be introduced on rooftop gardens is aquaponics. This technology combines recirculation aquaculture and hydroponics. In aquaponics, plants and fish are grown together in one integrated system. The fish waste is a source of nutrients for the growing plants and the plants act as a natural filter for the water the fish live in. This creates a sustainable ecosystem where both plants and fish can thrive. Aquaponics is the ideal answer to a fish farmer's problem of disposing of nutrient-rich water, and a hydroponic grower's need for that nutrient-rich water. Commercial growers and researchers around the world have had great success growing lettuce, leafy vegetables, tomatoes, cucumbers, peppers, melons, flowers and many other crops using this method while at the same time raising fish such as tilapia, brim, bass, carp, etc.

Urban agriculture has its own requirements, such as growing vegetables in compact environments with less water and even without soil, using methods such as aeroponics.

Given that the Singapore Government's objective is to have local production comprise around 10 per cent of the annual consumption of leafy vegetables consumed each year (local production is currently at only 7 per cent of total consumption), urban agriculture using cutting-edge methods such as those described above could play a key role. Moreover, Singapore could help lead the world towards practical and economical ways to grow food on urban rooftops.

The success of such an endeavour will depend partly on raising public awareness about the needs and benefits of urban agriculture and the nutritional value of locally produced food. Innovative project financing, appropriate support mechanisms such as political, legal, operational and regulatory frameworks would need to be put in place to facilitate urban agricultural activities, move them into the formal economy, and address food safety and health concerns. The creative use of information and communication technologies can help transform Singapore's residents into urban farmers. Integrating subjects pertaining to urban food production and food security into university curricula would also contribute to changing the current mindset.

Playing a larger role in ASEAN food security

Despite Singapore's limited agricultural history and experience, it can play a significant role in regional food security. Its high level of economic development, strategic location, R&D capabilities, technology- and business-friendly environment, and stringent food safety standards allow Singapore to serve as an honest broker and 'neutral mediator' in a number of initiatives. From an R&D perspective, Singapore can serve as a knowledge platform for technical expertise and laboratory and market research. By harnessing the knowledge and expertise of its vibrant R&D community from both the public and private sectors, it can take the lead in areas such as improving seed varieties, variety selection and development of seed banks for vegetables, farming systems and post-harvest technologies for vegetables, breeding and farming systems for fish, and waste treatment systems. Moreover, Singapore's AVA can act as a technical referral point for assisting other ASEAN member countries in setting food safety standards. Singapore can also facilitate and inspire technology transfers, best practices, business models and standards. Such initiatives will allow Singapore to help empower rural farmers in its 'hinterlands' and improve their productive capacity.

One of the oft-cited reasons for declining global agricultural productivity is the under-investment in rural infrastructure and agricultural innovation. Given Singapore's role as a regional and stable financial centre, it can also serve as a catalyst to bring venture investment funds into agriculture in the region. Further, Singapore's efficient port and logistics and its proximity to major commodity producing and consuming countries could also help it establish itself as a regional processing and distribution hub. It currently is the regional base of more than 50 global agribusiness firms including some of the top global grain traders such as Cargill, Bunge, Noble and Louis Dreyfus. Finally, because of its strategic location, Singapore could also play a role in strengthening capacity within ASEAN's integrated food security information system to more effectively anticipate future shortages or disruptions in food supply which affect overall food security in the region.

Given that Singapore's economic growth and GDP are driven significantly by the tourism sector and its ability to attract a sizeable number of expatriate talents, a stable food security situation is essential for the economy to thrive. The number of tourists is anticipated to surpass 10 million per year, mostly from Asia (Malaysia, Indonesia, China, etc.), and if a conservative 60 per cent of these stay for an average of 3 days and consume 250 grammes of rice daily, an additional 4.5 million tonnes of rice would be needed each year. Rice is a commodity that has a 'thin' surplus margin for trade, and exports originate mainly from the 'hinterland' countries in the ASEAN region. Any disruption in supply would have major implications for the tourism industry of Singapore. The country, however, is not alone in viewing tourism as an important sector to drive economic growth as other ASEAN countries are also capitalising on this vibrant sector. There is therefore a common interest in assuring the stability of food availability. By helping others help themselves in their 'hinterlands', Singapore can help assure not only its own food security but also contribute to that of the rest of the region.

Conclusion

In this paper, we have made the case for considering urban food security as an issue in its own right, while still recognising its strong inter-relationships to the wider discourse on food security and to the global food supply chain. When contextualised for a net food-importing country such as Singapore, the geographic distinctions of 'heartland' and 'hinterland' have been introduced to facilitate the juxtaposing of the four dimensions of food security with the sources of food supply and with the attributes associated with urban environments. The four dimensions of food security differ significantly in importance between urban and rural environments, and between net food importers and net food exporters. Food availability and distribution are vital elements in ensuring urban food security but are subject to externalities, some of which it is possible to develop anticipatory strategies for. The food security dimensions concerning economic access and utilisation are more appropriately considered as 'internal' dimensions falling within sovereign domains, but for which regional cooperation is beneficial. In conclusion, Singapore, as an urban city-state, cannot afford to allow its island status to prevent it from embarking on a broad-based, multi-sectoral, cross-nation approach to ensure urban food security. After all, food security at the national level depends also on regional and global food security.

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